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Injuries are common among those who engage in vigorous physical activity, particularly among military Basic Trainees. This is a unique population for the study of injuries as many potential confounders are controlled by the highly standardized environment. Previous studies of injury have identified body composition, physical fitness and gender as risk factors. Studies also indicate that women enter the Army less physically fit than their male counterparts. Hence, it is not clear whether the higher incidence of injuries among female trainees is due to their lower fitness or to gender per se.
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High Injury Rates Among Female Army Trainees: A Function of Gender?

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ABSTRACT

Injuries are common among those who engage in vigorous physical activity, particularly among military Basic Trainees. This is a unique population for the study of injuries as many potential confounders are controlled by the highly standardized environment.

Previous studies of injury have identified body composition, physical fitness and gender as risk factors. Studies also indicate that women enter the Army less physically fit than their male counterparts. Hence, it is not clear whether the higher incidence of injuries among female trainees is due to their lower fitness or to gender per se.

Eight-hundred and sixty-one trainees were followed during their 8 week basic training course. Demographic characteristics, body composition and physical fitness were assessed. Female trainees experienced twice as many injuries as male trainees, 57% versus 27%, respectively (RR = 2.1). When the injury and gender relationship was stratified on aerobic fitness, the gender differential was no longer significant. In multivariate analyses, including demographics, body composition and fitness independent variables, gender was not a significant predictor of injury overall, or of injuries serious enough to result in time lost from training. Significant risk factors were low physical fitness as measured by slow run time and poor sit up performance. White race was also associated with time-loss injury risk.

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INTRODUCTION

For most injury categories, men are at greater risk than women.[1] However, for sports and training injuries, studies suggest that, when exposure is controlled, women are actually at greater risk than men. This has been documented in a number of civilian as well as military studies.[2-11]

Military training populations offer two advantages for the study of gender and injury: First, the incidence of injuries is high; second, the regimented daily activities tend to equalize risk exposures for men and women. Many potential confounders of the gender and injury relationship are thereby eliminated in this unique environment.[9,10,12-18]

In addition to gender, percent body fat and lower physical fitness, as measured by sit ups and run times, are risk factors for injuries in the military.[12,13,19] Female basic trainees are less physically fit than their male counterparts on entry to basic training.[10,20,21] It is not clear how much the higher incidence of injuries among female trainees can be attributed to their lower fitness.

The primary purpose of this study is to examine the relative rates of injury for male and female Army trainees, controlling for physical fitness.[22]

METHODS

Eight-hundred and sixty-one Army trainees (509 men and 352 women) were followed during their eight week Basic Combat Training (BCT) course, in this prospective cohort study. The population of potential study volunteers included all women entering female training companies formed during one month, in the fall of 1988. One out of four male companies, selected on the basis of their proximity to the womens' units, were also included.

All potential volunteers were briefed on the study and offered the opportunity to participate (n=1075); 93% volunteered for the study and signed consent forms (n=1002). Anthropomorphic measures were not taken on 14% of these volunteers precluding them from analyses. Thus, the number of trainees studied for this analysis was 861.

Trainees were administered a baseline screening survey of demographics (gender, age and race), prior physical activity and health.[10,13] In addition, study staff assessed volunteer body composition and fitness. Body composition measures included height, weight and percent body fat. Fitness measures included flexibility, muscle strength, muscle endurance and aerobic fitness.[13]

Percent body fat was estimated by a series of circumference measurements.[20,24] Flexibility was measured by the use of a Bender-Box, which assesses range of motion, in a sitting position, stretching over the toes.[12] Muscle strength was estimated through an isometric test of maximum hand grip force.[20] Muscle endurance and aerobic fitness were measured through the initial Army physical fitness test. This included maximal push ups and sit ups, and one mile run times. Trainee fitness at the end of training was measured by test scores of maximal push ups, sit ups, and two mile run time.

To assess improvements in aerobic fitness, the end of training two mile run times were converted to their one mile run time equivalents. Run times are highly correlated with maximum oxygen consumption (VO_2 max.), a measure of aerobic capacity.[21,22] Using a table listing VO_2 max. and run times for various distances, one mile run times and equivalent two mile run times were matched using their corresponding VO_2 max. values.[23]

Medical records for the training period were reviewed every two to three weeks and all injury diagnoses transcribed. Diagnoses were made by clinic physicians who were blinded to patients' participation in the study.

Injury occurrence was defined by any condition causing a trainee to seek medical care which resulted in an injury diagnosis. An injury leading to one or more days of lost duty, was used as a measure of serious injury.

For analysis, all subjects were split into one of five roughly equal sized groups (quintiles) based on performance, from low to high levels. Since lower fitness is associated with higher injury risk, the most fit groups were used as the low-risk, comparison group for analyses. Chi-square analysis was used to test the significance of risk ratios and the Mantel-Haenszel chi-square for trend was used to test for linear associations.

Multivariate models were constructed in an incremental, hierarchical process, using logistic regression analyses. Variables were grouped into quintiles to facilitate analyses and interpretation of findings.[12,13,27,28]

Height and percent body fat, as potential markers for gender, may create problems of multicollinearity. Both factors were excluded from the final multivariate model. However, inclusion or exclusion of these variables from the multivariate model did not influence the estimated gender coefficient.

RESULTS

The mean age of men was 20.1; the mean age of women was 20.4. Fifty-eight percent of men were white, 33% black, and 9% other; women were 43% white, 48% black, and 9% other. Table 1 provides descriptive and fitness characteristics of the male and female study participants. Men exhibited significantly higher levels of physical fitness than women on all measures except flexibility.

TABLE1--Body Composition and Physical Fitness of Study Population (n=861)

Characteristic	MEN Mean	Std Dev	WOMEN Mean	Std Dev	T-Test (p)
HEIGHT(cm)	175.1	(7.3)	162.0	(6.4)	.01
WEIGHT(kg)	76.3	(12.3)	57.8	(6.3)	.00
BODYFAT(%)	16.4	(5.6)	26.6	(4.0)	.00
STRENGTH(kg)	117.2	(21.1)	67.3	(13.2)	.00
FLEXIBLE(cm)	34.8	(6.3)	32.6	(5.9)	.26
1MI RUN(min)	7.6	(0.9)	10.1	(1.6)	.00
SITUPS(n)	43.7	(11.6)	30.9	(13.9)	.00
PUSHUPS(n)	32.4	(12.4)	10.9	(7.4)	.00
END 2M RUN	14.0	(1.1)	17.4	(1.4)	.00
END SITUPS	63.0	(10.4)	61.3	(11.9)	.05
END PUSHUPS	49.8	(12.2)	27.9	(10.4)	.00

At the end of the training cycle men still did more push ups and ran faster than women, but women narrowed the gap considerably, particularly through their situp performance (figure 1 and Table 1). Women's sit ups improved by 98%, versus 44% for the men; push ups improved by 156% compared to 54% for the men. Womens' aerobic fitness improved by 23% compared to 16% for men.

Figure 1
% Improvement in Fitness Scores

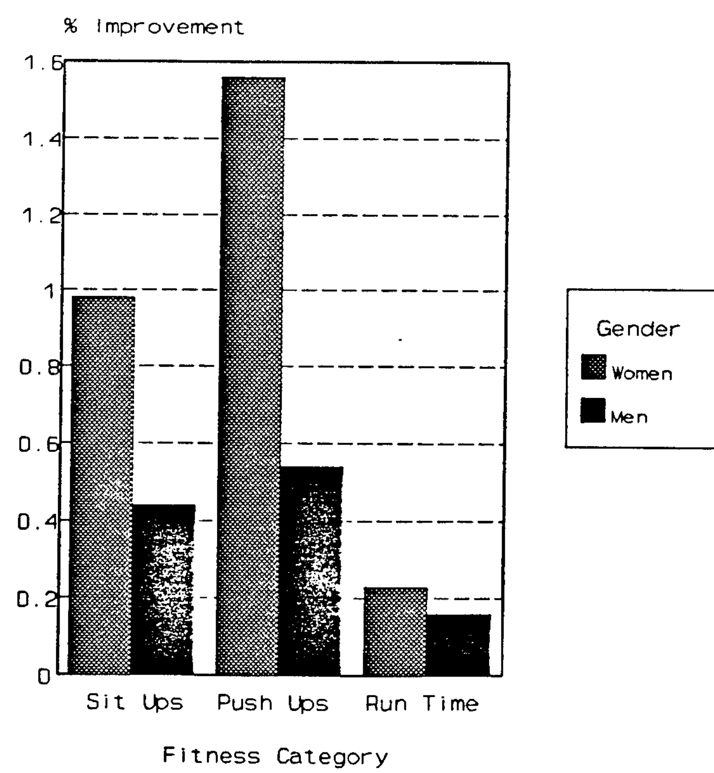


Table 2 shows the cumulative incidence of injury for men and women with one or more injury. Women experienced about twice as many injuries as men both for all injury clinic visits and for injury visits resulting in lost training time. Most injuries, for men and women, were to the lower extremity (foot, lower leg) and were musculoskeletal in nature.

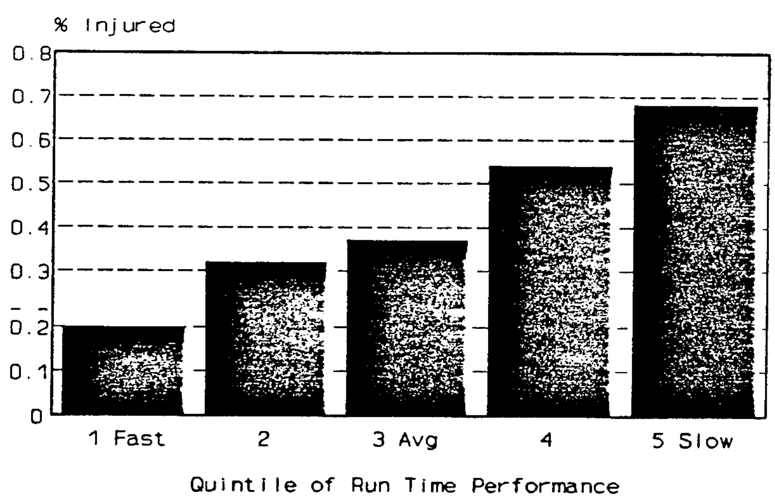
TABLE 2--Cumulative Incidence (Percentage) of Injury (N=861)

INJURY	MEN	WOMEN	RR*	95% C.I.
One or More	27%	57%	2.1	(1.78-2.50)
With Time-Loss	17%	41%	2.4	(1.92-3.05)

* (p) < .000000

Figure 2 depicts the association of injury with aerobic fitness (run times). The figure depicts the step-wise significant trend of higher risk of injury for successively lower levels of aerobic fitness (i.e. slower run times). The slowest runners have almost three and a half times greater risk of experiencing an injury than the fastest runners.

Figure 2
Injury Incidence and Mile Run Time



MH Chi-Square for Trend = 87.9, (p<.000)

Table 3 shows the gender and injury relationship stratified by aerobic fitness (run times). For the fast trainees, the relative risk of injury, for women versus men, was near 1 (RR = 1.04, p = .78). The injury risks for women were close to the risk for men within each quintile of run time suggesting that aerobic fitness explains much of the injury risk differential.

Table 3--Gender and Relative Risk of Injury Stratified on Run Times

RUN TIME	RELATIVE RISK (Women vs Men)	95% Confidence Intervals	(p) Values
2. Fast	1.04	(0.4 - 2.7)	0.78
3. Average	1.52	(1.0 - 2.3)	0.09
4. Slow	1.17	(0.8 - 1.7)	0.45
5. Slowest	1.37	(0.5 - 3.7)	0.81

* The fastest run group was too sparse for calculation of a relative risk (only 1 female trainee in the stratum)

The results of a logistic model of one or more injury regressed on gender and other demographic, body composition and fitness risk factors, are found in Table 4. Key findings are: 1) gender was not significant when other demographic and physical fitness factors were controlled; and 2) slow run time was the only significant predictor of injury.

TABLE 4--Multiple Logistic Regression Analysis. One or more injury visit regressed on Demographic and Fitness Risk Factors.

RISK FACTORS		Estimated Coefficients	95% Confidence Intervals
Sex	1 = Men	----	
	2 = Women	1.14	0.48 - 2.72
Race	1 = Black	----	
	2 = White	1.31	0.89 - 1.94
	3 = Other	0.84	0.40 - 1.79
Age	1 = < 20	----	
	2 = 20-24	1.50	1.00 - 2.23
	3 = 25+	1.26	0.69 - 2.31
Run Time*	1 = Fast	----	
	2	1.47	0.68 - 3.18
	3 = Avg	1.54	0.91 - 2.62
	4	2.52	1.26 - 5.04
	5 = Slow	3.23	1.59 - 6.58
Situps	1 = High	----	
	2	1.05	0.60 - 1.81
	3 = Avg	0.80	0.44 - 1.44
	4	1.15	0.63 - 2.09
	5 = Low	1.51	0.78 - 2.92
Pushups	1 = High	----	
	2	1.62	0.90 - 2.92
	3 = Avg	1.19	0.65 - 2.19
	4	1.34	0.66 - 2.71
	5 = Low	1.24	0.54 - 2.88
Strength	1 = High	----	
	2	1.41	0.80 - 2.50
	3 = Avg	1.61	0.90 - 2.88
	4	2.10	0.88 - 5.04
	5 = Low	2.11	0.83 - 5.36

* = (p) < .05

Table 5 shows the results of one or more time-loss injury regressed on the same predictors as in the previous model. Once again, gender was not significant, while run time was. White race was also a significant risk factor for time-loss injuries. Poor situp performance may also be a risk factor.

TABLE 5--Multiple Logistic Regression Analysis. One or more time-loss injury visit regressed on Demographic and Fitness Risk Factors.

RISK FACTORS		Estimated Coefficients	95% Confidence Intervals
Sex	1 = Men	----	
	2 = Women	1.29	0.50 - 3.34
Race*	1 = Black	----	
	2 = White	2.13	1.37 - 3.32
	3 = Other	1.15	0.48 - 2.74
Age	1 = < 20	----	
	2 = 20-24	1.39	0.90 - 2.14
	3 = 25+	0.96	0.49 - 1.86
Run Time*	1 = Fast	----	
	2	1.69	0.84 - 3.43
	3 = Avg	1.55	0.81 - 2.97
	4	2.00	0.88 - 4.58
	5 = Slow	3.72	1.64 - 8.45
Situps	1 = High	----	
	2	1.10	0.59 - 2.04
	3 = Avg	0.56	0.28 - 1.14
	4	1.18	0.61 - 2.29
	5 = Low	1.68	0.83 - 3.40
Pushups	1 = High	----	
	2	1.26	0.63 - 2.50
	3 = Avg	1.02	0.50 - 2.06
	4	1.17	0.52 - 2.60
	5 = Low	1.06	0.42 - 2.70
Strength	1 = High	----	
	2	1.06	0.54 - 2.05
	3 = Avg	1.33	0.69 - 2.57
	4	2.14	0.83 - 5.51
	5 = Low	0.93	0.34 - 2.58

* = (p) < .05

DISCUSSION

The crude injury rates indicated that women were at higher injury risk than men. The fitness adjusted rates, however, showed no significant gender difference in risk. Much of the gender-injury relationship appears to be explained by physical fitness, in particular aerobic fitness.

The demographic and fitness characteristics, as well as the injury rates of trainees in this study were similar to previous military training studies.[8,9,20] The association between physical fitness and injury was also similar to past studies.[10,12,29] This suggests that our findings are generalizable to other military training populations.

The observed associations between injury, run time and sit ups have a scientific theoretical basis. Most injuries were to the lower extremity, related to weight-bearing activities, so run time, as a marker for weight-bearing fitness, is particularly relevant to predicting these types of injuries.[8,13] In addition, run times have been shown to correlate very highly (r = .90) with laboratory measures of aerobic capacity (VO_2 max.).[21] Aerobic capacity, a reflection of the body's ability to use oxygen when

physically challenged, may be a good measure of overall conditioning or physical fitness.[30]

Sit ups were bordering on significance in the time-loss injury model. Other military studies have identified sit up performance as a significant predictor of injury.[29] Sit up performance may reflect both muscle endurance and lower extremity muscle strength, as the iliopsoas muscle is involved in performing situps. More lower-extremity muscle strength may be protective, particularly against lower extremity injuries--the type most commonly observed in this population.[10,12]

Women had smaller variances than men in mean values for all demographic, body composition, and fitness measures, except sit ups and run times. For these risk factors women had larger standard deviations than men suggesting that perhaps these two variables were better discriminators of overall physical fitness for women than the other variables.

This analyses and results contribute to the current literature on fitness, gender and injury in the following ways:

1) The prospective, cohort design, as well as the similar risk exposures of the trainees, allowed for better control of potential confounders. Men and women in this population had very similar risk exposures. They completed the same training objectives; lived in similar conditions; adhered to the same daily schedules; were offered the same diet; and had the same access to health care.

2) Military populations are probably more representative of the general population and represent a broader range of fitness levels than competitive athletes, the subjects of many civilian studies.[30]

3) There is not a lot of information available on the risk factors for training injuries, and in particular the role of gender.[10,31-33] Few studies have included all of these demographic, body composition and fitness factors. Those that have included some of these factors did not employ multivariate methods. We were able to examine the influence of a potential risk factor, such as gender, while controlling for the effects of other factors.

It is possible that multicollinearity may dilute some of the gender influence in the multivariate model. However, in bivariate analyses, when the gender-injury relationship was stratified on run times, injury differences were no longer significant, suggesting that aerobic fitness, rather than multicollinearity, was probably the major reason gender was not significant in the multivariate model.

CONCLUSION

Our results suggest that the key risk factors for training injuries are physical fitness, particularly cardiovascular fitness (run times). Gender, after controlling for fitness, is not significantly associated with injury; fitness, a covariate of gender, is.

The substantial improvements in endurance performance for women supports the conclusion that women enter training less physically fit relative to their own fitness potential as well as relative to men entering training. Our results demonstrate that women improve their levels of fitness at approximately twice the rate of men, substantially narrowing the fitness gap over the eight week training period. While women may not, on average, be able to perform at the same absolute level of fitness as men, they can substantially improve their performance with training.

Women and men of the same level of physical fitness can be expected to have similar injury risks when performing similar, physically demanding tasks or training. These results suggest that women and men initiating a vigorous physical training or exercise program, who exhibit low levels of physical fitness, are more likely to be injured by training activities, but will also improve their level of fitness more rapidly than their more fit peers. In the early phase of training it may be wise to start these people at lower, fitness-appropriate levels of training and progress slowly to more advanced training as their fitness improves.

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